

CLAIMS

1 1. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a seed cartridge having an aperture and containing at least a plurality of
4 radioisotope seeds preloaded into the cartridge;

5 a needle assembly; and

6 an implantation station including:

7 a base structure that positions an insertion axis relative to the patient;

8 a cartridge receiving structure defined along a portion of the insertion axis;

9 and

10 a Z-axis automated motion control system that selectively moves the
11 needle assembly along the insertion axis and into the patient and selectively ejects
12 radioisotope seeds from the aperture of the cartridge into the needle assembly
13 when the cartridge is positioned in the cartridge receiving structure.

14 2. The automated implantation system of claim 1 wherein the automated motion control
15 system moves the cartridge and the needle assembly together to maintain a relative position
16 between the cartridge and the needle assembly along the insertion axis.

17 3. An automated implantation system for implanting low dose radioisotope seeds in a
18 patient as part of a brachytherapy procedure comprising:

19 a storage structure adapted to hold a plurality of radioisotope seeds;

20 a needle assembly;

21 a Z-axis automated motion control system that selectively moves at least the
22 needle assembly along an insertion axis and into the patient and selectively ejects
23 radioisotope seeds from the storage structure into the needle assembly; and

8 an X-Y axis automated motion control system that selectively moves at least the
9 needle assembly in a plane perpendicular to the insertion axis to selectively position the
10 insertion axis relative to the patient.

1 4. The automated implantation system of claim 3 wherein the storage structure is a
2 replaceable cartridge and the system include cartridge receiving structure defined along at least a
3 portion of the insertion axis.

1 5. The automated implantation system of claim 4 wherein the Z axis automated motion
2 control system moves the cartridge and the needle assembly together to maintain a relative
3 position between the cartridge and the needle assembly along the insertion axis.

1 6. The automated implantation system of claim 3 wherein the automated implantation
2 system further comprises:

3 a computer processor operably connected to at least the Z-axis automated motion
4 control system and the X-Y axis automated motion control system and having a user
5 interface that displays information about the automated implantation system and accepts
6 commands from a user to control the process of implanting the plurality of radioisotope
7 seeds in the patient.

1 7. The automated implantation system of claim 6 wherein the user interface displays a grid
2 identifying a plurality of locations that are selectable by the user in the plane perpendicular to the
3 insertion axis where radioisotope seeds are to be implanted and the computer processor controls
4 the X-Y axis automated motion control system to position at least the needle assembly
5 perpendicular to a location selected by the user.

1 8. The automated implantation system of claim 7 wherein computer process selectively
2 rotates the grid within the plane perpendicular to the insertion axis so as to simulate a rotation of
3 the needle assembly with respect to the plane perpendicular to the insertion axis and then

4 recomputes the locations selected by the user in response to the rotation to achieve the rotation
5 without requiring that the needle assembly be physically rotated in the plane perpendicular to the
6 insertion axis.

1 9. The automated implantation system of claim 6 wherein the user interface includes at least
2 one direction control input mechanism that allows a user to selectively control at least the Z-axis
3 automated motion control system to control movement of at least the needle assembly along the
4 insertion axis and into the patient.

1 10. The automated implantation system of claim 9 wherein the direction control input
2 mechanism is a joystick.

1 11. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a storage structure adapted to hold a plurality of radioisotope seeds;

4 a needle assembly;

5 an ultrasound probe;

6 a first Z-axis automated motion control system that selectively moves at least the
7 needle assembly along an insertion axis and into the patient and selectively ejects
8 radioisotope seeds from the storage structure into the needle assembly;

9 a second Z-axis automated motion control system that selectively moves the
10 ultrasound probe in a probe axis generally parallel to the insertion axis; and

11 a computer processor operably connected to at least the second Z-axis automated
12 motion control systems and to the ultrasound probe such that the computer processor
13 utilizes the ultrasound probe to monitors a position of an organ being treated in the
14 brachytherapy procedure and selectively adjusts a base plane position of the insertion axis
15 relative to the organ.

1 12. The automated implantation system of claim 11 wherein the computer processor
2 automatically adjusts the base plane in response to a movement in the position of the organ
3 during the brachytherapy procedure.

1 13. The automated implantation system of claim 11 wherein the computer processor adjusts
2 the base plane in response to a user directive and all subsequent radioisotope seeds placed by the
3 implantation systems are placed at a depth determined from the adjusted base plane position.

1 14. The automated implantation system of claim 11 further comprising:

autofocus system operably connected to the ultrasound probe and the second Z axis automated motion control system such that the computer processor utilizes the autofocus system to automatically adjust the base plane position.

15. An automated implantation system for implanting low dose radioisotope seeds in a patient as part of a brachytherapy procedure comprising:

a storage structure adapted to hold a plurality of radioisotope seeds;

a needle assembly;

a Z-axis automated motion control system that selectively moves at least the needle assembly along an insertion axis and into the patient and selectively ejects radioisotope seeds from the storage structure into the needle assembly;

an ultrasound probe; and

a computer processor operably connected to the Z-axis automated motion control systems and to the ultrasound probe that captures and stores at least one image from the ultrasound probe with the needle assembly in position in the patient to selectively place at least one radioisotope seed so as to form a record of the brachytherapy procedure.

1 16. The automated implantation system of claim 15 wherein the implantation station further
2 comprises:

3 an X-Y axis automated motion control system that selectively moves at least the
4 needle assembly in a plane perpendicular to the insertion axis; and

5 wherein the computer processor captures and stores an image from the ultrasound
6 probe each time the needle assembly is located at a different position in the plane
7 perpendicular to the insertion axis by the X-Y axis automated motion control system.

1 17. The automated implantation system of claim 15 wherein the computer processor captures
2 and stores the at least one image from the ultrasound probe when the needle assembly is moved
3 forward along the insertion axis to a distal most location where radioisotope seeds will be placed.

1 18. The automated implantation system of claim 15 wherein the computer processor further
2 includes a user interface that displays information about the automated implantation system and
3 accepts commands from a user to control the process of implanting the plurality of radioisotope
4 seeds in the patient and wherein images from the ultrasound probe are displayed on the user
5 interface in a separate window on the user interface.

1 19. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a storage structure adapted to hold a plurality of radioisotope seeds;
4 a needle assembly;
5 a first Z-axis automated motion control system that selectively moves at least the
6 needle assembly along an insertion axis and into the patient and selectively ejects
7 radioisotope seeds from the storage structure into the needle assembly;

8 an ultrasound probe;
9 a second Z-axis automated motion control system that selectively moves the
10 ultrasound probe in a probe axis generally parallel to the insertion axis; and
11 a computer processor operably connected to at least the second Z-axis automated
12 motion control system that executes an autocalibration routine that automatically

13 calibrates the second Z-axis automated motion control system prior to utilizing the
14 ultrasound probe in the brachytherapy procedure.

1 20. The automated implantation system of claim 19 wherein the ultrasound probe is
2 replaceable and the computer processor determines an XYZ relationship of the ultrasound sound
3 probe to the needle assembly each time a different replaceable ultrasound probe is used with the
4 automated implantation system.

1 21. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a storage structure adapted to hold a plurality of radioisotope seeds;
4 a needle assembly including a needle coaxially located within a canula;
5 a needle automated motion control system that controls the needle; and
6 a canula automated motion control system that controls the canula separately from
7 the needle,

8 such that the needle automated motion control system and the canula automated
9 motion control system cooperate to initially move the needle and canula along an
10 insertion axis and into the patient and the needle automated motion control system
11 withdraws the needle to selectively ejects radioisotope seeds from storage structure into
12 the canula.

1 22. The automated implantation system of claim 21 wherein the needle automated motion
2 control system and the canula automated motion control system initially move the needle and
3 canula along the insertion axis by repetitively advancing the needle a distance beyond the canula
4 and then advancing the canula that same distance.

1 23. The automated implantation system of claim 22 wherein the distance the needle
2 automated motion control system advances the needle beyond the canula ranges between 0.5 and
3 2.0 cm.

1 24. The automated implantation system of claim 21 wherein the canula automated motion
2 control system withdraws the canula once all the radioisotope seeds are positioned in the patient
3 with the needle automated motion control system keeping the needle in place until the canula is
4 withdrawn.

1 25. The automated implantation system of claim 21 wherein the storage structure further
2 includes a plurality of spacers and wherein the needle automated motion control system
3 selectively ejects a radioisotope seed and a spacer into the canula as a pair oriented
4 longitudinally along the insertion axis and advances the pair along the insertion axis by pushing
5 on the spacer with the needle.

1 26. The automated implantation system of claim 25 wherein the needle automated motion
2 control system withdraws the needle once the canula is positioned as desired to accept a plurality
3 of pairs each consisting of a radioisotope seed and a spacer in the canula and each pair is moved
4 along the insertion axis to a staging area in the canula proximal to a distal end of the canula until
5 all of the pairs for a current location of the canula are in the staging area after which the needle
6 automated motion control system advances all of the pairs along the insertion axis to the distal
7 end of the canula.

1 27. The automated implantation system of claim 26 wherein the canula automated motion
2 control system withdraws the canula once all the pairs are positioned at the distal end of the
3 canula with the needle automated motion control system keeping the needle in place until the
4 canula is withdrawn.

1 28. The automated implantation system of claim 26 wherein the canula includes at least one
2 annular wiping seal positioned along the insertion axis at an end of the staging area.

1 29. The automated implantation system of claim 21 wherein the needle automated motion
2 control system and the canula automated motion control system comprise a pair of synchronized
3 lead screw drives.

1 30. The automated implantation system of claim 21 wherein the needle automated motion
2 control system comprises a capstan drive system and the canula automated motion control
3 system comprises a lead screw drive.

1 31. The automated implantation system of claim 21 wherein the needle is selectively
2 replaceable in the needle automated motion control system.

1 32. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a seed cartridge having an aperture and containing at least a plurality of
4 radioisotope seeds preloaded into the cartridge;

5 a needle assembly;

6 a Z-axis automated motion control system that selectively moves at least the
7 needle assembly along an insertion axis and into the patient and selectively ejects
8 radioisotope seeds from the seed cartridge into the needle assembly; and

9 a force sensor that senses forces on the needle assembly along the insertion axis
10 and is operably connected to at least the needle automated motion control system.

1 33. The automated implantation system of claim 32 wherein the force sensor senses whether
2 the needle encounters resistance above an expected force for piercing tissue when the needle
3 automated motion control system advances the needle assembly and, in response, the needle
4 automated motion control system stops advancing the needle assembly.

1 34. The automated implantation system of claim 33 wherein the needle automated motion
2 control system is mounted in a compliant mount and the force sensor is mounted at a rear of the

3 needle automated motion control system, the compliant mount providing with a minimum travel
4 distance in the event that the needle assembly encounters resistance above the expected force for
5 piercing tissue that forms a safety buffer to allow the needle assembly to retract.

1 35. The automated implantation system of claim 33 wherein the force sensor comprises a
2 load cell mounted in a compliant mount at a rear of the needle assembly, the compliant mount
3 providing with a minimum travel distance in the event that the needle encounters resistance
4 above the expected force for piercing tissue that forms a safety buffer to allow the needle to
5 retract.

4 36. The automated implantation system of claim 32 wherein the force sensor senses whether
5 the needle assembly has advanced into a non-tissue region and, in response, a user interface
6 operably connected to the automated motion control system provides an indication to a user that
7 the needle assembly has advanced into the non-tissue region.

1 37. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 a storage structure adapted to hold a plurality of radioisotope seeds;

4 a needle assembly;

5 a Z-axis automated motion control system that selectively moves at least the
6 needle assembly along an insertion axis and into the patient and selectively ejects
7 radioisotope seeds from the storage structure into the needle assembly; and

8 a targeting indication system that demarks a location of where the insertion axis is
9 positioned on the patient during the brachytherapy procedure.

1 38. The automated implantation system of claim 37 wherein the targeting indication system
2 includes at least a plurality of light emitting devices that generate a corresponding plurality of
3 light beams on the location.

1 39. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:
3 a storage structure adapted to hold a plurality of radioisotope seeds;
4 a needle assembly;
5 a Z-axis automated motion control system that selectively moves at least the
6 needle assembly along an insertion axis and into the patient and selectively ejects
7 radioisotope seeds from the storage structure into the needle assembly; and
8 a base station that supports at least the Z-axis automated motion control system
9 and the needle assembly and positions the insertion axis relative to the patient, the base
10 station including:
11 a base;
12 a moveable assembly that includes the insertion axis and is orientable
13 independently of the base; and
14 a stand operably connected between the base and the moveable assembly.
15
16 40. The automated implantation system of claim 39 wherein the stand includes:
17 a gross vertical adjustment mechanism that adjusts a vertical height of the
18 moveable assembly relative to the base;
19 a rotation mechanism that pivots the moveable assembly about a vertical
20 axis relative to the base;
21 a lateral positioning mechanism that adjusts a lateral position of the
22 moveable assembly in relation to the vertical axis; and
23 a tilt mechanism that tilts the moveable assembly relative to a horizontal
24 plane perpendicular to vertical axis.
25
26 41. The automated implantation system of claim 40 wherein at least the gross vertical
27 adjustment mechanism is motorized.

1 42. The automated implantation system of claim 39 wherein the base includes a set of
2 retractable wheels that allows the implantation system to be moved when the wheels are
3 extended and provide a stable position for the implantation system when the wheels are
4 withdrawn.

1 43. The automated implantation system of claim 39 wherein the base station includes
2 alternative power sources, a primary power source that plugs into an external outlet and a
3 secondary power source connected to a battery housed in the base station, the secondary power
4 source configured to replace the primary power source in the event that the primary power
5 source is unplugged from the external outlet.

44. An automated implantation system for implanting low dose radioisotope seeds in a
patient as part of a brachytherapy procedure comprising:

1 a storage structure adapted to hold a plurality of radioisotope seeds;
2 a needle assembly;
3 an ultrasound probe having an outer rigid sheath coaxial with the ultrasound
4 probe;

5 a first Z-axis automated motion control system that selectively moves at least the
6 needle assembly along an insertion axis and selectively ejects radioisotope seeds from the
7 storage structure into the needle assembly;

8 a second Z-axis automated motion control system that selectively moves the
9 ultrasound probe in a probe axis generally parallel to the insertion axis such that the
10 second Z-axis automated motion control system initially positions both the outer sheath
11 and the ultrasound probe in the patient and then moves only the ultrasound probe along
12 the probe axis and within the sheath to generate ultrasound images along the probe axis.

1 45. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 cartridge receiving structure adapted to receive a cartridge containing a plurality
4 of radioisotope seeds;

5 a needle assembly;

6 carrier receiving structure adapted to receive a carrier structure containing an
7 ultrasound probe;

8 a first Z-axis automated motion control system that selectively moves at least the
9 needle assembly along an insertion axis and selectively ejects radioisotope seeds from the
10 storage structure into the needle assembly;

11 a second Z-axis automated motion control system that selectively moves the
12 ultrasound probe in a probe axis generally parallel to the axis of insertion.

46. The automated implantation system of claim 45 wherein the carrier structure includes a
mechanism to allow for rotation of the ultrasound probe relative to the probe axis and to
selectively lock the ultrasound probe in a desired rotation.

47. The automated implantation system of claim 45 wherein the needle assembly and the
cartridge are operably arranged in a common carrier structure and the carrier structure mates with
a cartridge receiving structure.

48. A method of operating an automated implantation system having a Z-axis automated
motion control system and an X-Y axis automated motion control system that control at least a
needle assembly for implanting low dose radioisotope seeds in a patient as part of a
brachytherapy procedure comprising:

- 5 (a) using the X-Y axis automated motion control system to position an insertion axis
6 of the needle assembly relative to the patient;
- 7 (b) using the Z-axis automated motion control system to selectively move the needle
8 assembly along the insertion axis to implant at least one radioisotope seed; and
- 9 (c) repeating steps (a) and (b) for a plurality of locations on a base plane
10 perpendicular to the insertion axis.

1 49. The method of claim 48 wherein the needle assembly comprises a needle coaxially
2 located within a canula and wherein the Z-axis automated motion control system comprises a
3 needle automated motion control system that controls the needle and a canula automated motion
4 control system that controls the canula and wherein step (b) comprises:

5 (b1) using the needle automated motion control system and the canula
6 automated motion control system to repetitively advancing the needle a
7 distance beyond the canula along the insertion axis and then advancing the
8 canula that same distance until the canula is positioned at a desired depth
9 relative to the base plane;

10 (b2) using the needle automated motion control system to withdraw the needle
11 once the canula is positioned at the desired depth to accept a radioisotope
12 seed and then advancing the needle to position the radioisotope seed in the
13 canula.

14 50. A method of operating an automated implantation system for implanting low dose
15 radioisotope seeds in a patient as part of a brachytherapy procedure comprising:

16 (a) using an ultrasound probe to establish a base plane for a position of an organ
17 being treated in the brachytherapy procedure;

18 (b) using the automated implantation system to implant low dose radioisotope seeds
19 in the patient with at least a Z-axis automated motion control system that implants
20 radioisotope seeds to a depth determined in relation to the base plane;

21 (c) monitoring the position of the organ during step (b); and

22 (d) automatically adjusting the base plane used in step (b) in response to any
23 movement in the position of the organ during the brachytherapy procedure.

24 51. A method of operating an automated implantation system having a Z-axis automated
25 motion control system and an X-Y axis automated motion control system that control at least a

3 needle assembly for implanting low dose radioisotope seeds in a patient as part of a
4 brachytherapy procedure comprising:

- 5 (a) providing an ultrasound probe to establish a base plane for a position of an organ
6 being treated in the brachytherapy procedure;
- 7 (b) using the automated implantation system to implant low dose radioisotope seeds
8 in the patient with the Z-axis automated motion control system implanting
9 radioisotope seeds along an insertion axis generally perpendicular to the base
10 plane and the X-Y automated motion control system moving the insertion axis in
11 the base plane;
- 12 (c) automatically capturing and storing at least one image from the ultrasound probe
13 for each unique position of the insertion axis in the base plane so as to form a
14 record of the brachytherapy procedure.

15 52. A method of operating an automated system for inserting a needle assembly for
16 implanting low dose radioisotope seeds in a patient as part of a brachytherapy procedure, the
17 needle assembly comprising a needle coaxially located within a canula and the automated system
18 comprising a needle automated motion control system that controls the needle and a canula
19 automated motion control system that controls the canula, the method comprising:

- 20 (a) positioning the needle assembly along an insertion axis relative to the patient;
- 21 (b) using the needle automated motion control system and the canula automated
22 motion control system to repetitively advancing the needle a distance beyond the
23 canula along the insertion axis and then advancing the canula that same distance
24 until the canula is positioned at a desired depth; and
- 25 (c) using the needle automated motion control system to withdraw the needle once
26 the canula is positioned at the desired depth to accept a radioisotope seed and then
27 advancing the needle to position the radioisotope seed in the canula.

1 53. The method of claim 52 wherein step (b) is performed such that the distance the needle
2 automated motion control system advances the needle beyond the canula ranges between 0.5 and
3 2.0 cm.

1 54. The method of claim 52 further comprising:

2 (d) using the canula automated motion control system to withdraw the canula once
3 the radioisotope seed is positioned with the needle automated motion control
4 system keeping the needle in place until the canula is withdrawn.

1 55. The method of claim 52 wherein automated system includes at least one cartridge
2 containing a plurality of radioisotopes seeds and a plurality of spacers and wherein step (c) is
3 performed such that a radioisotope seed and a spacer are ejected from the cartridge into the
4 canula as a pair oriented longitudinally along the insertion axis and needle automated motion
5 control system advances the pair along the insertion axis by pushing on the spacer with the
6 needle.

1 56. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;
4 a needle assembly; and
5 an implantation station including:
6 means for positioning an insertion axis relative to the patient;
7 means defined along a portion of the insertion axis for replaceably
8 receiving the means for storing; and
9 automated means for selectively moving the needle assembly along the
10 insertion axis and into the patient and selectively ejects radioisotope seeds from
11 the means for storing into the needle assembly.

1 57. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;
4 a needle assembly;
5 automated means for selectively moving the needle assembly along the insertion
6 axis and into the patient and selectively ejects radioisotope seeds from the means for
7 storing into the needle assembly; and
8 automated means for selectively moving at least the needle assembly in a plane
9 perpendicular to the insertion axis to selectively position the insertion axis relative to the
10 patient.

11 58. An automated implantation system for implanting low dose radioisotope seeds in a
12 patient as part of a brachytherapy procedure comprising:

13 means for storing at least a plurality of radioisotope seeds;
14 a needle assembly;
15 an ultrasound probe;
16 first automated means for selectively moving at least the needle assembly along
17 an insertion axis;
18 second automated means for selectively moving the ultrasound probe in a probe
19 axis generally parallel to the insertion axis; and
20 a computer processor means operably connected to at least the second automated
21 means and to the ultrasound probe for monitoring a position of an organ being treated in
22 the brachytherapy procedure and selectively adjusting a base plane position of the
23 insertion axis relative to the organ.

24 59. An automated implantation system for implanting low dose radioisotope seeds in a
25 patient as part of a brachytherapy procedure comprising:

26 means for storing at least a plurality of radioisotope seeds;
27 a needle assembly;

5 automated means for selectively moving at least the needle assembly along an
6 insertion axis and into the patient and selectively ejecting radioisotope seeds from the
7 means for storing into the needle assembly;

8 an ultrasound probe; and

9 a computer processor means operably connected to the automated means and to
10 the ultrasound probe for capturing and storing at least one image from the ultrasound
11 probe with the needle assembly in position in the patient to selectively place at least one
12 radioisotope seed.

1 60. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;

4 a needle assembly;

5 an ultrasound probe;

6 a first automated means for selectively moving at least the needle assembly along
7 an insertion axis and for selectively ejecting radioisotope seeds from the storage structure
8 into the needle assembly;

9 a second automated means for selectively moving the ultrasound probe in a probe
10 axis generally parallel to the insertion axis; and

11 a computer processor operably connected to at least the second automated means,
12 including means for automatically calibrating the second automated means prior to
13 utilizing the ultrasound probe in the brachytherapy procedure.

1 61. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;

4 a needle coaxially located within a canula;

5 first automated means for controlling movement of the needle along an insertion
6 axis; and

7 second automated means for controlling movement of the canula along the
8 insertion axis.

1 62. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;

4 a needle assembly;

5 automated means for selectively moving at least the needle assembly along an
6 insertion axis and selectively ejecting radioisotope seeds from the means for storing into
7 the needle assembly; and

8 means operably connected to the automated means for sensing forces on the
9 needle assembly along the insertion axis.

1 63. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;

4 a needle assembly;

5 automated means for selectively moving at least the needle assembly along an
6 insertion axis and selectively ejecting radioisotope seeds from the means for storing into
7 the needle assembly; and

8 means for targeting a location of where the insertion axis is positioned on the
9 patient.

1 64. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 means for storing at least a plurality of radioisotope seeds;

4 a needle assembly;

5 automated means for selectively moving at least the needle assembly along an
6 insertion axis and selectively ejecting radioisotope seeds from the means for storing into
7 the needle assembly; and

8 a base station that supports at least the automated means and the needle assembly
9 and positions the insertion axis relative to the patient, the base station including:

10 a base;

11 a moveable assembly that includes the insertion axis; and

12 means operably connected between the base and the moveable assembly
13 for orienting the moveable assembly independently of the base.

5 65. The automated implantation system of claim 64 wherein the means for orienting includes:

6 means for adjusting a vertical height of the moveable assembly relative to
7 the base;

8 means for pivoting the moveable assembly about a vertical axis relative to
9 the base;

10 means for adjusting a lateral position of the moveable assembly in relation
11 to the vertical axis; and

12 means for tilting the moveable assembly relative to a horizontal plane
13 perpendicular to vertical axis.

1 66. An automated implantation system for implanting low dose radioisotope seeds in a
2 patient as part of a brachytherapy procedure comprising:

3 cartridge receiving structure adapted to receive a cartridge containing a plurality
4 of radioisotope seeds;

5 a needle assembly;

6 carrier receiving structure adapted to receive a carrier structure containing an
7 ultrasound probe;

8 first automated means for selectively moving at least the needle assembly along
9 an insertion axis and selectively ejecting radioisotope seeds from the cartridge;

10 second automated means for selectively moving the ultrasound probe in a probe
11 axis generally parallel to the axis of insertion.

1 67. An automated system for controlling insertion of a needle assembly into a patient along
2 an insertion axis, the needle assembly having a needle coaxially located within a canula, the
3 automated system comprising:

4 base structure that positions the insertion axis relative to the patient, the
5 base structure having a base, a moveable assembly that is orientable
6 independently of the base and includes structure defined along a portion of the
7 insertion axis to receive the needle assembly and, and structure operably
8 connected between the base and the moveable assembly;

9 a Z-axis automated motion control system that selectively moves the
10 needle assembly along the insertion axis when the needle assembly is positioned
11 in the moveable assembly, wherein the Z-axis automated motion control system
12 comprises:

13 a needle automated motion control system that controls the needle;
14 and

15 a canula automated motion control system that controls the canula;
16 an X-Y axis automated motion control system that selectively moves at
17 least the needle assembly in a plane perpendicular to the insertion axis; and

18 a computer processor operably connected to at least the Z-axis automated
19 motion control system and the X-Y axis automated motion control system and
20 having a user interface that displays information about the automated implantation
21 system and accepts commands from a user to control the process of inserting the
22 needle assembly.

1 68. The automated system of claim 67 wherein the needle automated motion control system
2 and the canula automated motion control system cooperate to initially move the needle and

3 canula along the insertion axis by repetitively advancing the needle a distance beyond the canula
4 and then advancing the canula that same distance.

1 69. The automated system of claim 67 wherein the needle automated motion control system
2 and the canula automated motion control system comprise a pair of synchronized lead screw
3 drives.

1 70. The automated system of claim 67 wherein the needle assembly includes a force sensor
2 operably connected to at least the needle and to the needle automated motion control system.

1 71. The automated system of claim 70 wherein the force sensor senses whether the needle
2 encounters resistance above an expected force for piercing tissue when the needle automated
3 motion control system advances the needle and, in response, the needle automated motion
4 control system stops advancing the needle.

1 72. The automated system of claim 71 wherein the force sensor comprises a load cell
2 mounted in a compliant mount at a rear of capstan drive assembly that moves the needle, the
3 compliant mount providing with a minimum travel distance in the event that the needle
4 encounters resistance above the expected force for piercing tissue that forms a safety buffer to
5 allow the needle to retract.

1 73. The automated system of claim 70 wherein the force sensor senses whether the needle
2 has advanced into a non-tissue region and, in response, provides an indication to a user via the
3 user interface that the needle has advanced into the non-tissue region.

1 74. A method of operating an automated system for inserting a needle assembly in a patient
2 as part of a medical procedure, the needle assembly comprising a needle coaxially located within
3 a canula and the automated system comprising a needle automated motion control system that
4 controls the needle, a canula automated motion control system that controls the canula and a

5 force sensor operably connected to at least the needle and to the needle automated motion control
6 system, the method comprising:

7 (a) positioning the needle assembly along an insertion axis relative to the patient;
8 (b) using the needle automated motion control system and the canula automated
9 motion control system to repetitively advancing the needle a distance beyond the
10 canula along the insertion axis and then advancing the canula that same distance
11 until the canula is positioned at a desired depth; and
12 (c) in the event that the force sensor senses the needle has encountered resistance
13 above an expected force for piercing tissue when the needle automated motion
14 control system advances the needle in step (b), using the needle automated motion
15 control system to stops advancing the needle.